CEREAL SCIENCE today

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DECEMBER 1960 VOLUME 5 NUMBER 10

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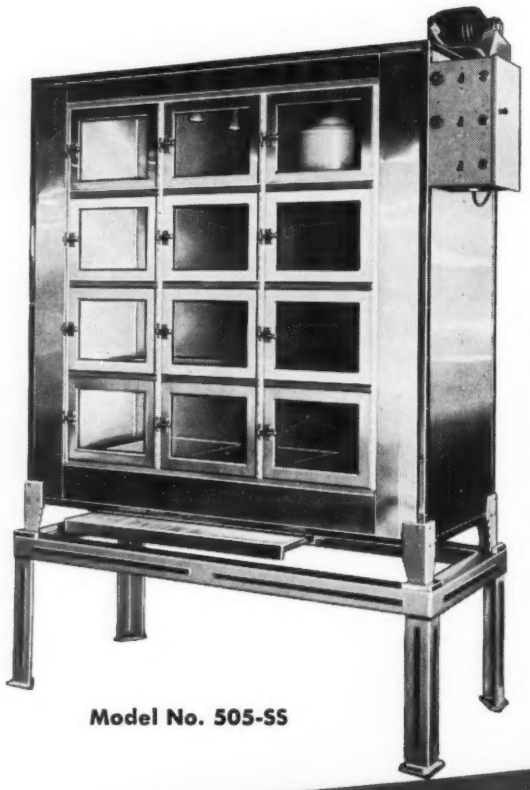

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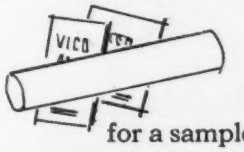

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American Association of Cereal Chemists

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The American Association of Cereal Chemists is devoted to: 1) the encouragement of scientific and technical research on cereal grains and their products; 2) the study of development and standardization of analytical methods used in cereal chemistry; 3) the promotion of the spirit of scientific cooperation among all workers in the field of cereal chemistry; 4) the maintenance of high professional standards of its membership; and 5) the encouragement of a general recognition of the value of the chemist and biologist to the cereal industries.

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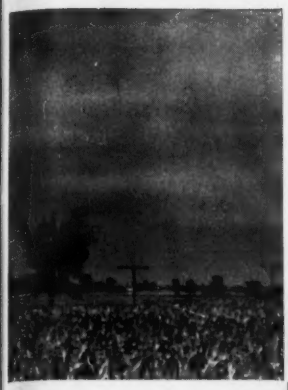

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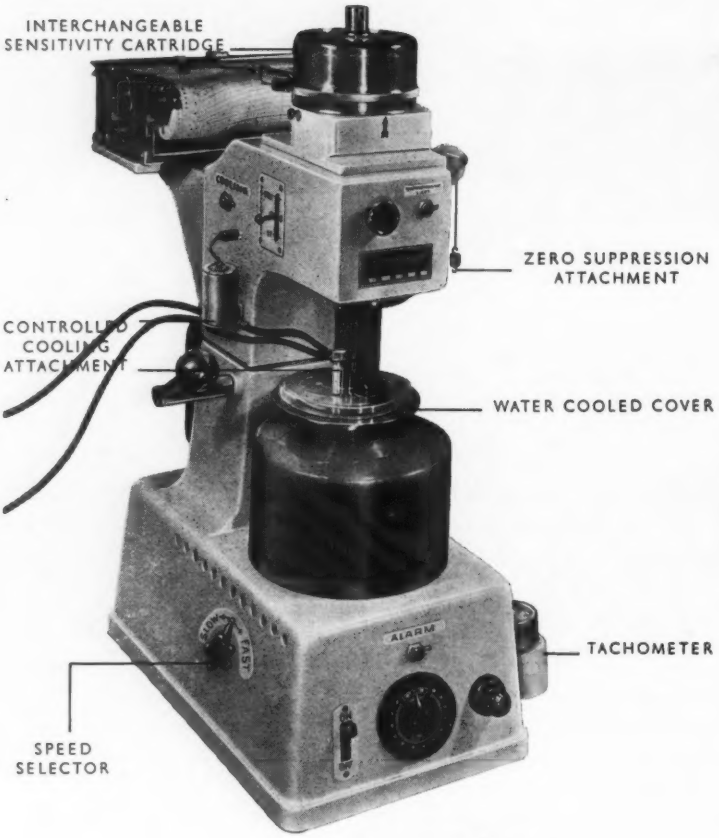

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Editorial

UTILIZATION OF ANALYTICAL chemists in industry was the subject of a symposium at the fall meeting of the American Chemical Society. Panelists were selected to provide a variety of viewpoints on the subject. The report of this feature which appeared in the November, 1960, issue of ANALYTICAL CHEMISTRY should be required reading for all chemists and for all who hire, evaluate, and decide the proper rewards for chemists.

There are differences in the manner in which employers select, motivate and recognize the contributions of their chemists. There are equally great differences in the training, orientation, and capabilities of individual chemists. No doubt problems exist which if solved would result in greater productivity on the one hand and enhanced job satisfaction on the other. The solutions are more easily suggested than implemented.

The need seems to be not so much for one group to convince the other of the rightness of its thinking as for each to recognize the benefits that it may gain through better understanding of the other's viewpoint. Only education can effectively counteract ignorance. Too often programs intended to accomplish this fail because they are so general that nothing worthwhile is said or only one side of the picture is presented.

Those who planned and participated in the ACS symposium sought to look objectively at all facets of their subject. They should be commended for their efforts.

PAUL E. RAMSTAD

CURRENT RESEARCH ON

The Biochemistry of Grain Storage[1]

By Pekka Linko, Department of Flour and Feed Milling Industries, Kansas State University, Manhattan, Kansas

UNTIL QUITE RECENTLY, little attention has been paid to the fundamenal biochemistry of grain storage. Although both storage deterioration and seed germination have been studied extensively, the physiological activities of viable seeds at very early stages of water imbibition have been largely neglected. This is particularly true of moisture levels insufficient to result in germination, such as may be encountered during storage of grain. Yet it is generally recognized that the quality of stored grain decreases with increasing moisture content, and that during prolonged storage, particularly at elevated temperatures, deterioration may be excessive at relatively low moisture levels. However, a certain minimum water activity evidently is necessary for metabolic reactions in general (8). It has been suggested that water relationships of such biocolloids as starch and, especially, proteins would determine to a great extent the vital activities and aging of living organisms. An understanding of the basic biochemical mechanisms involved would enable us to reduce losses due to spoilage of grain in storage, as well as to develop better means of detecting deterioration at its early stages when the quality of grain has not yet markedly decreased. This paper is largely a review of the recent work at Kansas State University on the biochemistry of grain storage.

Gas Exchange

Respiratory activity is very low in insect-free "air-dry" grains, and then is almost entirely due to the embryos. A mere increase in the relative humidity accelerates carbon dioxide evolution from the wheat germ (14). It has been known for a long time that an increase in moisture content results in a slow, steady increase in gas exchange until a certain "critical" moisture level is reached. Bailey and Gurjar (1) explained the sharp increase in the respiratory rate above this "critical" moisture level by suggesting that exceeding the water-binding capacity of biocolloids provides "free" water for metabolic reactions. However, owing to the relatively low metabolic activity of the embryo, the respiration and heating trends of stored grain at moisture levels below that required for germination were difficult to explain, until it was discovered that the "critical" moisture level coincides with the moisture requirements of certain saprophytic fungi frequently associated with storage deterioration. Since this observation was made, the importance of molds in the relationship between the moisture content and respiratory activity of stored grain has become well established (5,6). The "critical" moisture level varies from species to species, depending largely on the chemical composition. For wheat the value 14.6% is generally assigned. For further details the reader is referred to the comprehensive review on the earlier work on grain respiration by Milner and Geddes (21).

Recently it has become clear that in addition to fungal respiration the metabolism of the embryo itself is materially affected at low moisture levels, resulting in deleterious biochemical changes before fungal development reaches a damaging level. Several workers have shown that significant carbon dioxide evolution takes place at moisture levels below the germination requirement immediately on wetting of the embryo, resulting in highly elevated respiratory quotient (RQ) values (19). This excessive carbon dioxide evolution subsides hours before the germination of fungal spores affects the subsequent respiratory pattern. These results indicated that enzymatic processes would be stimulated by increasing the moisture content of "air-dry" embryos.

A study on the relationship of tricarboxylic acid cycle intermediates with the carbon dioxide evolution revealed that pyruvate and, to a lesser degree, alpha-ketoglutarate were readily decarboxylated by wheat germ (14). Simultaneously, pyruvate slightly inhibited oxygen uptake, resulting in very high RQ values for the gas exchange. The high RQ values observed immediately after wetting of wheat embryos could not, however, be explained by the activation of an alpha-keto acid decarboxylase, because of the small quantities of pyruvic and alpha-ketoglutaric acids in the germ (15). Recently the observation that glutamic acid decarboxylase is readily activated by adding water to wheat embryos (3, 16) led to the discovery that the enzymatic decarboxylation of glutamic acid is the major cause for the carbon dioxide evolution after wetting (4).

The high RQ values characteristic for the early stages of water imbibition decrease with time and

[1] Contribution No. 345, Department of Flour and Feed Milling Industries, Kansas Agricultural Experiment Station, Manhattan.

increasing moisture content, generally approaching unity in a few hours (1). The oxygen uptake increases correspondingly. Some workers have explained the high initial RQ values by irregularities in the diffusion of gases during the experiments at low moisture levels. Others have reported that a release of colloidally adsorbed gases may have a pronounced effect on the determination of the RQ. Presently it seems likely that metabolism during early stages of water imbibition actually is anaerobic, and that local transitory increases in moisture content, above the level necessary to activate the oxygen uptake mechanism, cause occasional fluctuation of the observed RQ values before moisture equilibrium is reached.

Enzyme Activation

Although the respiratory rate of bulk grain is greatly accelerated at moisture levels as low as 14% because of increased fungal activity, the moisture content of respiring fungal cells themselves is probably much higher. Yet it is known that wheat deteriorates slowly at relatively low moisture levels, even when environmental conditions prevent the fungal growth. Hence, the moisture levels required to activate various enzyme systems in the embryo become important in storage of cereal grain. It has been observed that wheat dampened and then dried exhibits a greater susceptibility to germ damage in subsequent storage than does undampened wheat of the same moisture level. A short dampening period evidently is enough to initiate deteriorative processes owing to the action of temporarily activated enzymes.

Swanson (25) first investigated the relationship between moisture content and enzyme activity in wheat. He observed an increase in amylase activity only after the grain reached 27% moisture content, and concluded that 27 to 30% moisture is enough to initiate the secretion, or activation, of amylase, but that 40% moisture is necessary to carry on the subsequent process. Swanson's discovery could not, however, explain the deterioration of grain at moisture levels as low as 14 to 15%.

The marked changes reported recently (15) in the composition of free amino and keto acids of wheat embryos even at relatively low moisture levels indicated the activation of several enzyme systems, including proteolytic enzymes. It could be shown both by conventional (16) and tracer (8) techniques that the moisture content required to activate glutamic acid decarboxylase and glutamic acid-alanine transaminase in wheat germ is between 15 and 18%. A similar study concerning the wheat embryo dehydrogenase system revealed that approximately 40% moisture is necessary for any material increase in enzyme activity (8). Figure 1 illustrates the results obtained.

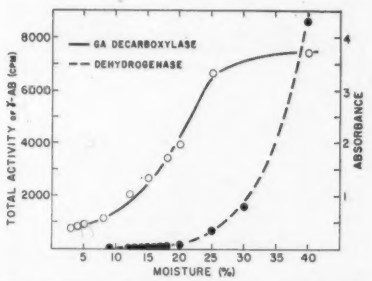


Fig. 1. Effect of moisture content on glutamic acid decarboxylase activity (illustrated by the formation of gamma-aminobutyric acid from radioactive glutamic acid) and on dehydrogenase activity (illustrated by the formation of formazan from 2,3,5-tetrazolium chloride).

"Free" and "Bound" Water

The concept of "bound" water becomes important during evaluation of the relationship between "critical" moisture content and activation of enzymes. Although no sharp boundary can be established between "free" and "bound" water in biological systems because the quantity of "bound" water observed largely depends on the method of estimation, "bound" water apparently plays a highly significant role in physiological processes. It seems clear that a certain minimum amount of more or less tightly "bound" water is necessary to activate enzyme proteins, and that a certain degree of "freedom" is necessary for water to act as a medium for metabolic reactions and for the translocation of intermediates. It has been postulated that the steady increase in electrical conductivity of deteriorating grain would be due to the release of "bound" water without an apparent change in the total moisture content.

Although the deteriorative processes in stored grains begins in the embryo, little work has been done concerning the water-binding capacity of embryo proteins. The changes in consistency, as measured by the farinograph, are closely related to the adsorption of water by proteins. Subsequently, the moisture content required to obtain the maximum consistency would reflect the maximum quantity of water that embryo proteins are capable of holding. Figure 2 shows typical farinograph curves for wheat germ at various moisture levels. When the water content was extrapolated to the maximum consistency, approximately 29% was obtained for the quantity of "bound" water (8). The binding forces decrease rapidly above this moisture level, the consistency approaching zero at about 60% moisture. Furthermore, the swelling pressure, which depends on the initial degree of swelling and hydration, approached zero when the original moisture content of wheat germ approached 40%.

The results from these studies indicated that wheat embryo proteins reach their limit to "bind" water at approximately 40% moisture level. Water in excess of about

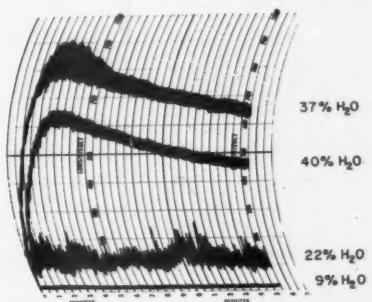


Fig. 2. Effect of moisture content on the consistency of wheat germ (50 g., d.m.) as measured by the Brabender Farinograph.

29% is apparently relatively loosely held, becoming increasingly available for transportation. Certain enzymes become activated at much lower moisture levels, causing an accumulation of vital metabolic intermediates; the "critical" moisture content for the activation of glutamic acid decarboxylase, transaminases, and proteases is between 13 and 16% (8). Others, such as the dehydrogenase system

and amylases, are activated only when the proteins become saturated with water and water becomes available for translocation.

Nonenzymatic Browning and Germ Damage

A condition generally known as germ-damaged or "sick" wheat may develop during storage, particularly if grain has been through extensive periods at elevated moisture levels. Germ damage is characterized by a more or less darkened embryo, which has lost viability. Such grain may, however, have a quite normal appearance, discoloration of the embryo becoming noticeable only after the removal of the bran layer covering the germ. Though it has been known for some time (18) that germ damage can develop in the absence of fungi, the heavy mold growth often associated with "sick" embryos led some workers to believe that toxic compounds secreted by fungi were the primary cause of damage.

Pearce (23) observed that the increased fluorescence of a wheat germ extract was related to the extent of damage, and he concluded that the deterioration of proteins would be chiefly responsible for the spoilage. Milner and co-workers (20) speculated on the possibility of a Maillard-type nonenzymatic browning reaction, involving free amino acids and reducing sugars, as a cause of germ damage in wheat. Although the total quantity of free amino acids in stored wheat has been reported to be affected little during the early stages of deterioration (26), Jones and Gersdorff (1) observed that prolonged storage of wheat and milled wheat products decreased protein nitrogen and increased free amino acid nitrogen. Recent evidence indicates that a considerable change in the composition of free amino acids and of the closely related keto acids may take place in wheat immediately following wetting (8, 15). The most characteristic change is a rapid decrease of the quantity of free glutamic acid, accompanied by a corresponding increase of free gamma-aminobutyric acid and, later, by increases of most of the free amino acids due to proteolysis. Subsequently though the total quantity of free amino acids manifests a significant increase only at advanced stages of deterioration, changes of the individual free amino acids appeared to be of some value in estimating the storage condition of wheat. Paper chromatography (9) and, particularly, paper electrophoresis (11) of amino acids seemed promising in evaluating these changes. Figure 3 shows typical electrophoresis patterns of the free amino acids of sound and damaged wheats. A relatively high glutamic acid peak, with low peaks for aspartic and basic amino acids and virtually no detectable gamma-aminobutyric acid peak, is characteristic of good-quality wheats of high germination percentage. The peak height ratio glutamic acid/aspartic acid averaged 2.8 in these wheats, and decreased with increasing deterioration to below 1.0. When viability decreases, glutamic acid peak generally decreases, followed invariably by a more or less marked gamma-aminobutyric acid peak. If a high gamma-aminobutyric acid peak is accompanied by both high glutamic acid and basic amino acid peaks, deterioration is very extensive and wheat has probably been dead for a long time under unfavorable storage conditions.

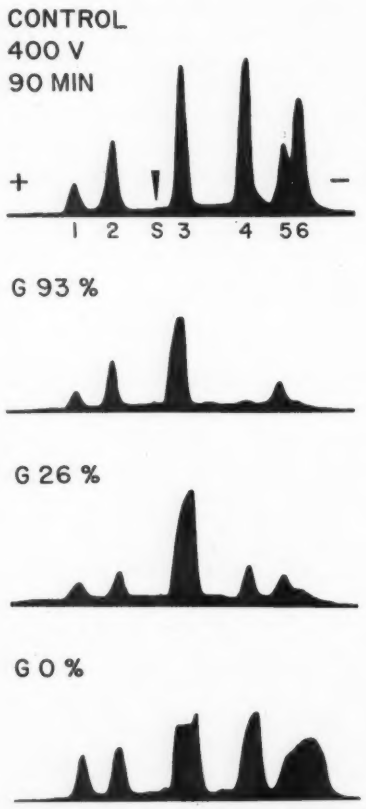


Fig. 3. Paper electrophoresis patterns of free amino acids of commercial wheats (0.025M potassium-hydrogen-phthalate, pH 4.0, 90 minutes at 400 V). Control run with authentic amino acids. G, % germination; S, point of application; 1, aspartic acid; 2, glutamic acid; 3, neutral group; 4, gamma-aminobutyric acid; 5, arginine; 6, lysine.

Several workers have observed that reducing sugars increase in grain stored at elevated moisture levels. Montgomery and Smith (22) suggested that the quantity and composition of soluble carbohydrates in wheat is likely to depend on the highest moisture level to which grain has been exposed. Linko, Cheng, and Milner (13) studied changes in the composition of soluble carbohydrates of wheat germ during storage at moisture levels and temperatures pertinent to conditions which produced germ-damaged wheat. They observed that the increases of reducing sugars, accompanied by decreases of nonreducing carbohydrates, preceded the appearance of browning which, in turn, was followed by an increase in fluorescence, particularly at moisture levels above 15%. Glucose and fructose did not increase as much as would have been expected from the breakdown of sucrose and raffinose, the difference likely being due to the reactions of reducing sugars with free amino acids.

It has been suggested that water imbibition first initiates the accumulation of compounds essential for cell division and for synthesis of new protoplasm in subsequent germination, and that a certain threshold level of vital intermediates is reached before the next phase of germination, characterized by rapid oxygen uptake and growth. If, however, the environmental conditions are unfavorable, and the water content does not reach the necessary level for this advanced state of germination, the formed free amino acids will eventually react with reducing sugars to form brown pigments characteristic of damaged wheat embryos. Thus, although the primary deteriorative processes resulting in germ damage appear to involve the metabolism of the embryo itself, the conditions also become more favorable for fungal growth. Subse-

quently the enzymatic processes associated with fungal growth may greatly accelerate the development of germ damage.

Glutamic Acid Decarboxylase Activity as Quality Index of Wheat

The importance of quick and reliable tests to estimate the quality of stored wheat is generally recognized, and numerous attempts have been made to determine the storage condition of cereal grains. Fat acidity has been widely used to evaluate wheat, but though basically simple, the standard method is somewhat time-consuming.

The metabolic rate and viability of grain are largely characterized by the activity of various enzymes, low activity being often associated with unfavorable storage conditions. Amylase, catalase, dehydrogenase, and peroxide activities have been previously related with the viability of various seeds. It was recently discovered that glutamic acid decarboxylase activity decreases during storage of wheat, especially at moisture levels above 15% (2). Consequently, it could be shown that glutamic acid decarboxylase activity provided a good index of the storage condition (10,17), and a simple and rapid manometric method was developed for its determination (12). Carbon dioxide evolution by 30 g. of ground wheat from 15 ml. of 0.1 molar glumatic acid in 0.067 molar phosphate buffer of pH 5.8 was measured with Sandstedt-Blish pressuremeters, using ethyl lactate as manometer liquid. A complete analysis of 10 samples could be performed in about 90 minutes. As shown in Fig. 4, a logarithmic relationship exists between the germination percentage and observed pressure increase, the correlation coefficient between viability and log pressure increase being r = +0.928***. This was significantly higher (at .12% level) than the correlation involving fat acidity. It appeared also that with few exceptions only samples above approximately 80% germination gave pressure increases more than 100 mm. ethyl lactate per 30 minutes per 30°C. (200 on the scale in Fig. 4). Because wheat above 75% germination is generally considered acceptable, the test appeared to provide a simple way to estimate

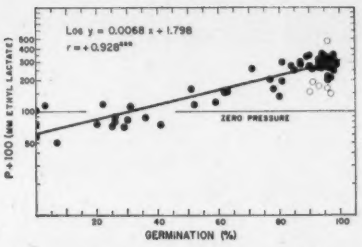


Fig. 4. Relations between glutamic acid decarboxylase activity and viability. Shaded area indicates the 95% confidence belt for the sample mean. White circles represent Langdon (above regression line) and Ponca (below regression line) wheats.

the quality of stored wheat. One variety (Ponca) was found to possess unusually low and one (Langdon) an unusually high glutamic acid decarboxylase activity, but these differences were significant only in wheats of high viability. Some evidence has indicated that pyruvic acid decarboxylase (carboxylase) activity would be less dependent on variety (17).

Glutamic acid decarboxylase activity of wheat may also be used to estimate probable storage time under any given average temperature and moisture conditions. Figure 5 shows a nomogram constructed for this purpose, using data of Linko (12) and Roberts (24). However, because wheat may be subjected to a variety of deteriorative processes it is obvious that a single nomogram cannot cover all the possible storage conditions; it rather gives an idea what would be likely to happen. The probable half-viability time at any given temperature and moisture conditions is readily obtained from scale *B* at the intersection of a straight line drawn

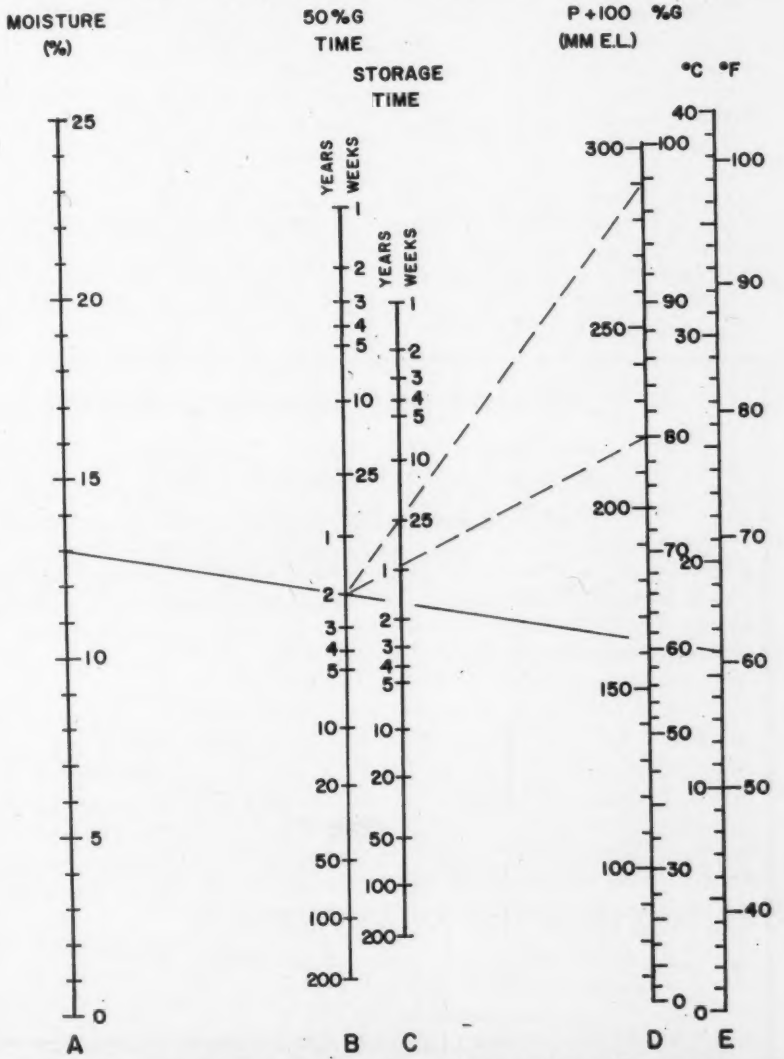


Fig. 5. A nomogram for the estimation of probable storage time of wheat at different moistures and temperatures from the glutamic acid decarboxylase activity. G, germination; E.L., ethyl lactate.

through the proper points on scales *A* and *E*. When a straight line is drawn from this intersection to the observed pressure reading on scale *D*, it will intersect scale *C* at the point of probable storage time. To find out for how long wheat could be stored to keep the germination percentage at or above any desired level, an additional line is drawn between the half-viability point on scale *B* and the desired germination percentage on scale *D*. The time between the two intersections on scale *C* shows the probable storage time left under the specified conditions.

Discussion

Recent research clearly indicates that several enzyme systems are activated in wheat embryos at relatively low moisture levels. Of greatest significance is the activation of glutamic acid decarboxylase and proteolytic enzymes. The former is chiefly responsible for the carbon dioxide evolution from freshly wetted wheat. As a result, free glutamic acid is rapidly dissipated, and this is followed by an increase in free gamma-aminobutyric acid. At advanced stages of deterioration, proteolysis results in increases of most of the free amino acids. Thus the composition of the free amino acids may be used as an index for storage deterioration.

Glutamic acid decarboxylase activity itself is affected by storage conditions and has been shown to be a good index of the storage quality of wheat. The condition of grain when put into storage is also an important factor for maintaining high quality in subsequent storage. A determination of glutamic acid decarboxylase activity would indicate if the grain has been exposed to unfavorable conditions, such as repeated cycles of wetting and drying, after maturity and thus would be likely to be an inferior storage risk.

Much more research is still needed concerning the early changes associated with the loss of viability in storage. When a clear picture is obtained of the primary reactions which eventually will result in deterioration, means may be developed to slow down these processes to extend the storage life of grain.

Literature Cited

1. Bailey, C. H., and Gurjar, A. M. *J. Agr. Research 12:* 685 (1918).
2. Cheng, Y. M. S. Thesis, Kansas State University, Manhattan (1959).
3. Cheng, Y.-Y., Linko, P., and Milner, M. *Suomen Kemistilehti B31:* 333 (1958).
4. Cheng, Y.-Y., Linko, P., and Milner, M. Plant Physiol. *35:* 68 (1960).
5. Christensen, C. M. *Botan. Rev. 23:* 108 (1957).
6. Geddes, W. F. *Food Technol. 12:* (11): 7 (1958).
7. Jones, D. B., and Gersdorff, C. E. F. *Cereal Chem. 18:* 417 (1941).
8. Linko, P. *Ann. Acad. Sci. Fennicae AII:98* (1960).
9. Linko, P. *Suomen Kemistilehti B33:* 144 (1960).
10. Linko, P. *Suomen Kemistilehti B33:* 145 (1960).
11. Linko, P. *Cereal Chem.* (in press).
12. Linko, P. *J. Agr. Food. Chem.* (in press).
13. Linko, P., Cheng, Y.-Y., and Milner, M. *Cereal Chem. 37:* 548 (1960).
14. Linko, P., and Milner, M. *Cereal Chem. 36:* 274 (1959).
15. Linko, P., and Milner, M. *Cereal Chem. 36:* 280 (1959).
16. Linko, P., and Milner, M. *Plant Physiol. 35:* 68 (1960).
17. Linko, P., and Sogn, L. *Cereal Chem. 37:* 489 (1960).
18. Matz, S. A., and Milner, M. *Cereal Chem. 28:* 196 (1951).
19. McDonald, C. E., and Milner, M. *Cereal Chem. 31:* 279 (1954).
20. Milner, M., Christensen, C. M., and Geddes, W. F. *Cereal Chem. 24:* 23 (1947).
21. Milner, M., and Geddes, W. F. *In* Storage of cereal grains and their products, ed. by J. A. Anderson and A. W. Alcock; chap. IV. Am. Assoc. Cereal Chemists: St. Paul, Minn. (1954).
22. Montgomery, R., and Smith, F. *J. Agr. Food Chem. 4:* 716 (1956).
23. Pearce, J. A. *Can. J. Research C21:* 57 (1943).
24. Roberts, E. H. *Ann. Botany 24:* 12 (1960).
25. Swanson, C. O. *Cereal Chem. 12:* 89 (1935).
26. Zeleny, L., and Coleman, D. A. *Cereal Chem. 15:* 580 (1938).

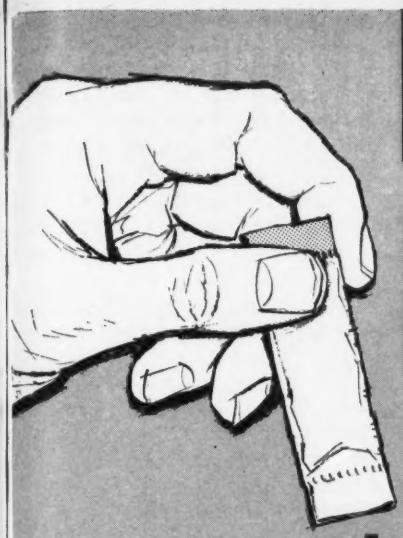
FINAL NOTICE – 46th ANNUAL MEETING

Members of the AACC wishing to present papers at the 46th Annual Meeting, April 9-13, 1961, in Dallas, should write immediately to the chairman of the session covering their field of interest.

The following sessions have been scheduled: *Pesticide Residues in Cereal Products,* Warren O. Edmonds, American Cyanamid Co., 3125 Gillham Plaza, Kansas City 9, Missouri; *Flavor Research,* Lazare Wiseblatt, American Institute of Baking, 400 E. Ontario St., Chicago 11, Illinois; *Feed Technology Session No. 1,* Robert C. Wornick, Chas. Pfizer and Co., Inc., Ag Research Dept., Terre Haute, Indiana; *Chemistry and Technology of Yeast,* Gerald Reed, Red Star Yeast and Products Co., 325 N. 27th St., Milwaukee, Wisconsin; *Feed Technology Session No. 2,* Max L. Cooley, Hoffman-Taff, Inc., Box 1246 S.S. Station, Springfield, Missouri; *Continuous Breadmaking,* William H. Ziemke, Safeway Stores, Inc., P.O. Box 1238, San Jose 26, California; *Starch Chemistry,* R. M. Sandstedt, Dept. Biochemistry and Nutrition, U. of Nebraska, Lincoln 3, Nebraska; *General Session,* Frank R. Schwain, Bulk Food Technical Services, Procter and Gamble Co., Winton Hill Tech. Center, Box 201, Cincinnati 24, Ohio; *Chemistry and Technology of Flour,* Kenneth Gilles, General Mills, Inc., 2010 E. Hennepin Ave., Minneapolis 13, Minnesota; *Useful Laboratory Techniques and Gadgets,* Lawrence L. Warren, Commander Larabee Milling Co., P.O. Box 356, Kansas City 41, Missouri; *Laboratory Layouts,* Grant W. Pearcy, The Pillsbury Company, 224 Second St., S.E., Minneapolis 14, Minnesota.

Byron S. Miller,
Program Chairman, Kansas State University, Manhattan, Kansas.
(Department of Flour and Feed Milling Industries)

THE LAST DATE FOR OFFERING PAPERS FOR PRESENTATION WILL BE DECEMBER 25, 1960



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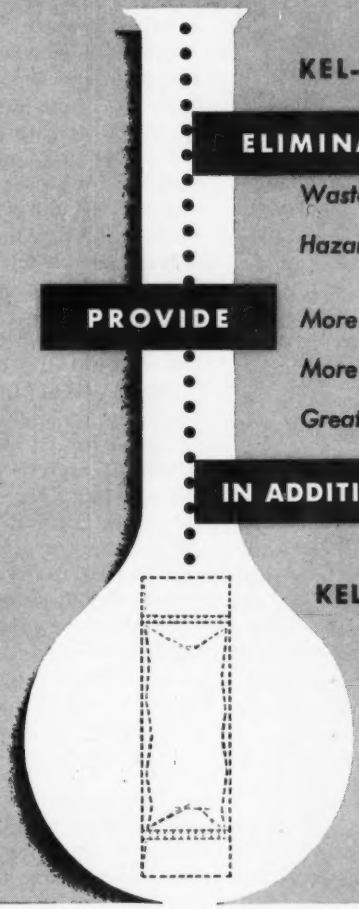

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THE CHEMIST'S ROLE IN

Modern Distillery Operations

By Irwin R. Sipherd, National Distillers Products Co., New York, N.Y.

STORIES ABOUT WHISKEY production and the universal use of alcoholic beverages have always had great popular appeal. In many instances the accounts have been exaggerated and distorted to fantastic proportions. The fact of the matter is that *true* stories about alcoholic beverage production abound, and are as fascinating as much of the fiction which has grown up about the subject.

Before we examine the many advances in distillery practices that have occurred during the past few years, it might be of interest to take a backward look at the history. References to vineyards, wines and wine production, and the use of alcoholic beverages are common in the Scriptures. It is written of Noah that he possessed vineyards and produced wine for his own use. Throughout all periods of history, there is evidence that fermented beverages were enjoyed by all classes of people.

The custom of making wine came as naturally to the inhabitants of the civilized world as the raising of dough in making bread. People learned from experience that wine made from their own grapes and certain other fermented liquids was safe to drink, whereas the water which was available may not have been safe for consumption. The use of wine, then, became a factor of self-preservation.

Distillation: An Ancient Art

The art of distillation, or the separation of alcohol, was not known until the age of Aristotle. There is an account in literature of a Greek physician being called away from his meal to perform a service. Before leaving the table, he placed a cover on a dish of vegetables to keep them hot until his return. When he was again seated at his table and uncovered the vegetables, he noticed that liquid had collected on the underside of the cover. From this he deduced that liquid had separated from the vegetables and condensed on the cover. On this observation the art of distillation is supposed to have been founded.

The separation of fermented liquids by distillation salvaged many food materials that normally would have been lost. Knowledge of the preservation of liquids, fruits, and foods was very limited. Little was known of sterilizing foods by heat or their preservation by refrigeration. However, experience had shown that separating the alcohol from a liquid which had been fermented by yeast produced a potable and palatable liquid that did not spoil. Knowledge of this separation spread throughout the populated world by word of mouth. Naturally, anything that fermented was tried by distillation. Those distillates that had a pleasing flavor remained as desirable beverages for human use – brandy from wines, arrach from koumiss, a fermented mare's milk, etc. Of course, where barley or rice was grown, the distillates of the beers were well known.

Throughout civilization and in almost every populated part of the world, fermented beverages and the distillation of alcoholic substances were known. Marco Polo is supposed to have learned much from the Chinese as to the finer arts of fermentation and distillation. During the ages the arts of fermentation and distillation were handed down from generation to generation by word of mouth, from father to son.

Era of the Chemist Begins

This practice continued until 1918, when prohibition in the United States broke the continuity of the handed-down method. Then the distiller – the one who knew the arts of fermentation – was indispensable, because no records were kept nor was the process discussed, for fear of giving away secrets. An aura of mystery prevailed, and new methods could not develop. With repeal in 1933, however, a new era started. Most of the masters had retired, and there were not enough sons who knew the arts to fill the demand. Now, vacancies were filled by men of curiosity and imagination, many of them fresh from college with a chemical degree. When the chemist was faced with the problem of fermentation and distillation, not having known of the past process, he had to use his own scientific knowledge in his attempt to produce the same product that the old masters had developed in their day. There were no articles of scientific study which would assist him, and no plant had a laboratory at his disposal.

The industry was so steeped in tradition and so confined by government regulations that the chemist had nothing to fall back on. For a time he was alone in his field, because strong tradition prevented him from discussing problems with chemists of other distilleries. Today we still are under restraint. It is difficult for us who are technically trained to understand why we may not discuss technical problems of fermentation

with other technical personnel in the same industry, and by so doing show progress as an industry. What progress we do make must be made within. Since 1933 progress has been made in this direction, but it has been hard to come by. Only during the last few years have substantial improvements been realized.

During the prohibition period only a few distilleries were permitted to operate for the production of medicinal whiskey. The only usable equipment at the time of repeal was in established plants – mild steel cookers, open wooden fermentors, open wooden yeast tubs, etc. Pure-culture fermentation was unheard-of, and pure fermentation was impossible. To emphasize this point, let me relate a remark made by an old-timer who worked in the plant. I had been trying to explain to him what I was trying to do and what I wanted him to stop doing. After I had finished my little talk, he turned to me and said, "Why, there ain't no such thing as a germ. Did you ever see one?"

New plants that were planned for construction had no guide to follow other than that which could be directed by the old master distiller. Many mistakes were made when new plants were assembled. Naturally, no improved methods were known because no research had been done.

Uniformity of Flavor

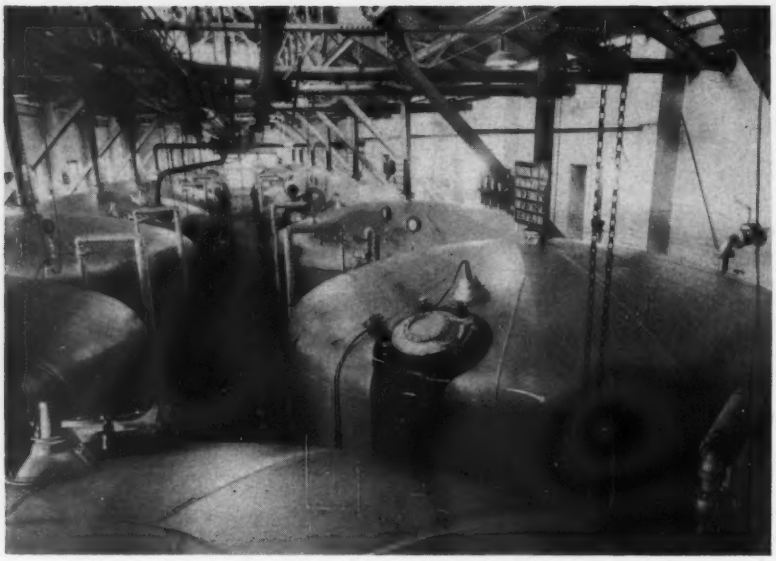
When the initial surge of business had declined a few years after repeal, the popularity of and demand for certain brands became quite apparent. The secret of this demand was not high-powered advertising, but the uniformity of quality and the consistently desirable flavor. The uniformity of flavor was the result of careful fermentation and distillation, combined with proper warehousing of the distillate in specially designed warehouses. This is something the old artisan could not achieve, particularly in regard to uniformity of flavor. Many whiskeys produced before 1918 had a flavor resulting from bacterial contamination of the fermented mash. To combat contamination, trained bacteriologists investigated the problem and progressive steps were taken to eliminate these sources. All process equipment, lines, valves, and coolers were changed to prevent pockets and other sources that would feed back contaminating bacteria. One would be amazed at the many valves in an old distillery that could feed back bacteria during the process. As bacterial contamination of fermentation was being eliminated, the efficiency of the fermentation increased. While the program of rehabilitation and improvement was being carried on in the distilleries, the question arose as to whether the flavor of the whiskey was being changed and whether the flavor from the bacteria was desirable. Through research and careful study, we recognized that a change was taking place as to flavor; but, comparing the new flavor with that of whiskeys made years ago, it was a desirable change. The difference is somewhat like that between the flavor of butter made in a modern and sanitary creamery and butter made on a farm, where the cream is accumulated for several days and kept in a water cooler before being churned. In our study we found no bacteria from an uncontrolled source that contributed desirable flavor; thus, as clean a fermentation as possible would be most desirable.

Since 1933, the actual beginning of scientific production of alcoholic beverages, the art of fermentation and distilling for whiskey production has advanced greatly. Uniformity of flavor and high efficiency of production resulted in a high-quality whiskey. All controls that could be applied were introduced, even to automation of the still operation. We learned that even though a satisfactory fermentation could be achieved, there was still a variation in flavor of the new whiskey according to the manner in which a still was operated. It was natural that the oldest still operator with the most experience would think that his method was the correct one, while the younger, less-experienced man on the night shift might not agree with him. The net result would be a difference in distillates from the same fermentation. To overcome this, the operation of the stills was placed on automatic controls and the limits precisely specified.

Control of Fermentation

In our quest for more complete control of fermentation, bacteriologists were brought in to investigate additional sources of contamination. When time and money permitted, the yeast tanks were changed from open wooden to enclosed stainless-steel or inconel pressure vessels, and enclosed pressure fermentors of copper-bearing steel replaced the open wooden fermentors. All lines and valves were streamlined. Through this combination, pure fermentation could be maintained.

Enclosed stainless steel yeast tubs with electric stirrers.



Stainless steel enclosed fermenting tanks with a 33,000 gallon capacity.

After all of these things had been achieved and as we approached pure fermentation, the bacteriologists found one source of contamination that could not be controlled by us. We realized that further amounts of money spent for sterilization would not achieve the goal. This source of contamination was traced directly to the barley malt used to convert the starches of the grain to fermentable sugars.

To make this understandable, I will relate briefly the manner in which the grains are cooked and converted for normal production of Kentucky-style whiskey. All of the ground corn and rye are mixed into warm water, making a homogeneous slurry, and heated to at least 212° F. At this temperature all of the viable bacteria are killed, leaving dormant spores that would not become active during the hours of fermentation with yeast. After the starches are thoroughly wetted by cooking, the mash, as we call it, is cooled to about 145° F. At this temperature the dry ground barley malt, or a slurry of malt in cold water, is added and thoroughly stirred in. The action of the alpha- and beta-amylase in the barley malt soon converts the starches into maltose. At this temperature only 63% of the starch is converted to sugar. The final conversion of the starches is made during fermentation at a much lower temperature. It is impossible to sterilize the mash containing the malt by heat, without killing the residual enzymes. Thus only a fraction of the bacteria on the malt is killed at 145° F. High-bacteria-bearing malt has a good chance to reinfect a sterile system.

Within the last few years a few malt companies have installed research laboratories, or have done some research on barley malt in behalf of the distilleries. As far as we could learn, there had been little or no change in the manner in which distiller's malt was made up to this time.

Role of Barley Malt

In regard to the barley malt that is so vital to our process, relatively little is known about it. We are aware that there are many enzymes in distiller's-type barley malt and we actually know a little about two enzymes which we can measure, alpha- and beta-amylase.

At the base of this stairwell is the automatic control board for operating the stills.

During the past 25 years, I have seen many grades of distiller's barley malt supplied to the distillers. A distiller had no basis upon which to reject it unless it was obviously bad. He had to accept many carloads of malt that had low enzymatic value and high bacterial count. When we began to study the two main factors that were very important to us, we found barley malt that had alpha-amylase as low as 25 units and a bacterial count as high as 50 million cells per g. It became very apparent that we had progressed as far as we could, and any further modernization of our plants would be useless.

For many years past we had been installing equipment and spending large sums of money in an effort to eliminate contamination from the fermentation and to increase efficiency of production. However, the use of low-quality malt was constantly defeating our efforts by introducing large quantities of viable bacteria into the process. We were certain that if we could use a malt that did not carry acid-forming or enzyme-destroying bacteria, a more complete after-conversion could be achieved.

To sell this idea to the maltsters who had been following the same program for several generations, we invited technical representatives from several malt suppliers to visit our plants. We showed them our plant operations and solicited their assistance in overcoming our problem. They were very receptive to the idea and immediately inaugurated a program to correct the condition. I commend the barley malt industry, which has made it possible to bring about the greatest achievement in the history of the distillery industry. The maltsters met the challenge, and they now supply us with a barley malt that has a bacterial count below 250,000 cells per g. Once we had this count established, we could evaluate the enzymatic effect of the malt. They now furnish us with

(Please turn to page 322)

MERRY CHRISTMAS AND HAPPY NEW YEAR
FROM NATIONAL YEAST
FRANK J. HALE, President

THE RELATION BETWEEN Protein Nutrition and Feed Formulation[1]

By H. W. Bruins and R. O. Nesheim, The Quaker Oats Co., Barrington, Ill.

SINCE PROTEIN is the basic material from which the main products of animal agriculture – meat, milk and eggs – are made, it is not surprising that protein nutrition assumes a pre-eminent place in feed formulation. Supplying protein for the ruminant is not so complex, because the microorganisms in the rumen can utilize simple nitrogenous compounds and the animal, in turn, secures the amino acids it needs by digesting the microorganisms. The monogastric, on the other hand, must be supplied each of nine to eleven essential amino acids, preformed in the feed, in order to synthesize the tissue or the products for which the animal is fed. Protein nutrition for these animals then becomes a problem of supplying the correct amounts of amino acids. The ensuing remarks will be restricted to the problem of protein nutrition for the monogastric.

Since the nonruminating animal requires preformed amino acids in its diet, "protein" *per se* has no meaning except insofar as it implies a source of amino acids. "Protein" requirements or determinations of crude protein by the Kjeldahl method have less meaning as our knowledge of amino acid requirement and balance increases. Still, "Kjeldahl N" is of considerable practical importance to the feed nutritionist because of its status in law – protein guarantees are required on feeds – and as a convenient abbreviation to use in referring to the total amino acid supply.

In commercial feed production, supplying amino acids falls into three logical steps both from the standpoint of research and from that of practical formulation. First, it is necessary to define the requirement for amino acids in the particular feed being formulated. Second, the various sources of amino acids must be examined and combined to achieve the best possible biological efficiency and the greatest economy. Third, quality-control procedures must be established to ensure that the amino acids assumed to be present are, in fact, not only present but fully available to the animal.

Definition of Amino Acid Requirement

In feed formulation, obviously the first step is the definition of what the feed is intended to accomplish. In providing proper amino acid nutrition a number of variables, discussed below, have been shown to influence the requirement.

Species. Table I lists the amino acid requirement for chickens and pigs, both in terms of percent of diet and as a percent of the total protein (3,9). The principal difference of importance here is the fact that the chicken requires glycine while the pig does not. This is a reflection of the fact that the chicken excretes nitrogen principally as uric acid, requiring one mole of glycine for each mole of uric acid, while the pig excretes predominantly urea. The chick also requires about five times as much arginine, as percent of protein, reflecting its inability to synthesize this amino acid. Mammals seem to synthesize arginine at appreciable rates, depending on species and age. Other differences in requirement are merely quantitative and, in view of our inexact knowledge of requirements, may not be as great as they appear.

Age and Rate of Growth. As an animal grows, tissue synthesis *de*

Table I. Amino Acid Requirement of Chicks and Pigs

	Starting Chicks[a] *(0–8 wks.)*		*Weanling Pigs*[b] *(about 50 lb.)*	
	Percent of Diet	*Percent of Protein*	*Percent of Diet*	*Percent of Protein*
Protein level	20.0	..	16.0	...
Amino acid:				
Arginine	1.2	6.0	0.20	1.25
Glycine	1.0	5.0	(not required)	
Histidine	0.3[c]	1.5	0.23	1.44
Isoleucine	0.60	3.0	0.52	3.25
Leucine	1.40	7.0	0.67	4.19
Lysine	0.90	4.5	0.74	4.62
Methionine	0.45	2.25	0.30	1.88
Total S a.a.[d]	0.80	4.0	0.50	3.12
Phenylalanine	0.90	4.5	0.38	2.38
Total aromatic a.a.	1.60	8.0	0.54	3.38
Threonine	0.60	3.0	0.45	2.81
Tryptophan	0.20	1.0	0.12	0.75
Valine	0.80	4.0	0.46	2.88

[a] See reference 9.
[b] See reference 3.
[c] See reference 11.
[d] Synthetic amino acid.

[1] Presented at the 45th annual meeting, Chicago, Ill., May 1960.

novo declines and tissue repair increases. Thus, quantitatively the amino acid requirement is reduced. Less is known about qualitative changes with increasing age, but the adult rat apparently requires no arginine for maintenance. Whether other changes in qualitative requirement for amino acids occur is open to speculation.

Purpose for Which Animal Is Fed. During the course of a year, a good hen will synthesize her own weight in high-quality egg protein. To do this she must, of course, draw the essential amino acids from the feed she consumes and may deposit as much as 60% of the total methionine from her feed into the egg. It follows, then, that the laying hen's requirements for amino acids are going to be different from those of a cockerel simply being maintained.

The kind of carcass desired also influences the decision on how much protein to put in a feed. Figure 1 shows that in ducklings

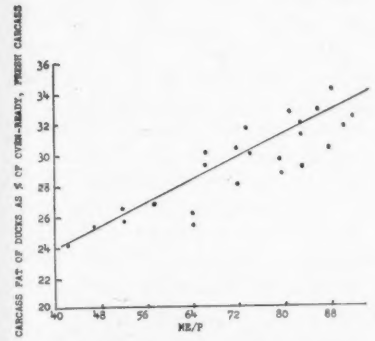
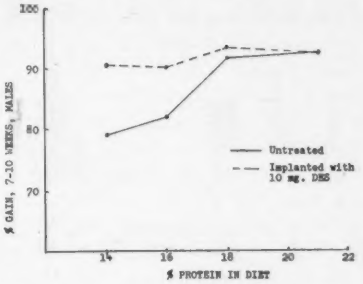


Fig. 1. Relationship between carcass fat content and dietary ME/P ratios in ducklings at 7½ weeks of age. (See ref. 11; reprinted by permission of the journal Poultry Science.)

higher-protein diets (lower ME/P ratios) produce a leaner carcass (11). The feed nutritionist must then know what kind of product the ultimate consumer wants, and, of course, what she will pay for.

Unusual Physiological Status. In certain physiological states the animal may have higher or lower requirements for specific amino acids. For example, the molting hen may require an unusual amount of sulfur amino acids for new feather growth. In Fig. 2, it is shown that chickens treated with diethylstilbestrol, a synthetic estrogen, apparently require much less protein than untreated controls. No doubt

Fig. 2. Effect of diethylstilbestrol (DES) on protein requirement of cockerels. (See ref. 5; reprinted by permission of the journal Poultry Science.)



this is due to the stimulus to lay down fat (5).

Protein Level. As the total supply of amino acids increases, the requirement for a particular amino acid also increases, but at a decreasing rate. This is illustrated in Fig. 3 (6). Thus, if an amino acid is in short supply, it is possible to achieve maximum growth by increasing the total protein level; but this is a wasteful process, since it actually requires more of the limiting amino acid.

Energy Level. In feed circles

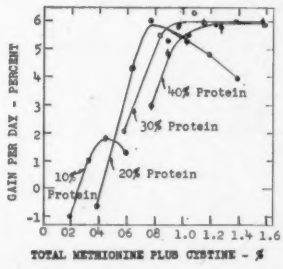


Fig. 3. Effect of protein level on the chick requirement for methionine plus cystine. Each point represents a group of eight chicks. (See ref. 6; reprinted by permission of the Journal of Nutrition.)

there has been much interest in the past few years in the relationship of energy content of the diet to the requirement for various nutrients (Fig. 4) (2). Actually, this

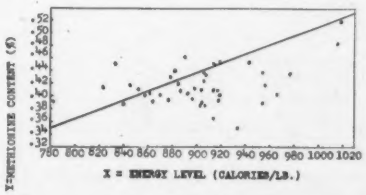


Fig. 4. Methionine and energy content of various diets in relation to their response to supplemental DL-methionine. Circles indicate diets improved by DL-methionine. Y = 0.000736; X = 0.2269. (See ref. 2; reprinted by permission of the journal Poultry Science.)

interest is largely a result of the fact that for convenience the feed nutritionist terms requirements as a percent of the diet. When the energy content of a diet is increased, the animal eats less of it. As a result it is not surprising that a nutrient, as a percent of diet, must be increased proportionately to the reduction in feed intake. Had we based requirements on the average daily intake at the outset, much of the difficulty could have been avoided.

Sources of Amino Acids

Having defined the amino acid requirements for a particular feed, the nutritionist must then look for sources of the amino acids to meet the requirement. While a single ingredient is rarely used as the sole source of protein, it is useful for our purposes to compare the Amino Acid Profile of various ingredients with the chick requirement for each amino acid. This approach immediately points up the deficiencies and surpluses of a given protein and makes it easier to determine possible mutually supplementary protein sources. These will be discussed briefly.

Grains. The grain portion of a feed, while included primarily as an energy source, may contribute from as little as 15% of the total nitrogen in feeds for turkey poults to as high as two-thirds of the total nitrogen in finishing diets for swine. Thus it is important to consider the strong points and weaknesses of grain in supplying amino acids. Figure 5, top, shows the Amino Acid Profile of common cereals. Lysine is the first limiting amino acid in most of the cereal grains. Since oats is relatively high in this amino acid, as the sole source of protein it shows the highest value in standard rat-feeding tests.

Vegetable Proteins. In all parts of the world we must generally rely on vegetable proteins to supply the bulk of the nitrogen. Since most vegetable proteins are also deficient in lysine, there is a real problem in supplementing cereal grains. In the U.S. we are fortunate in having an ample supply of soybean meal which, like other legume proteins, is relatively rich in this amino acid. (Fig. 5, middle.)

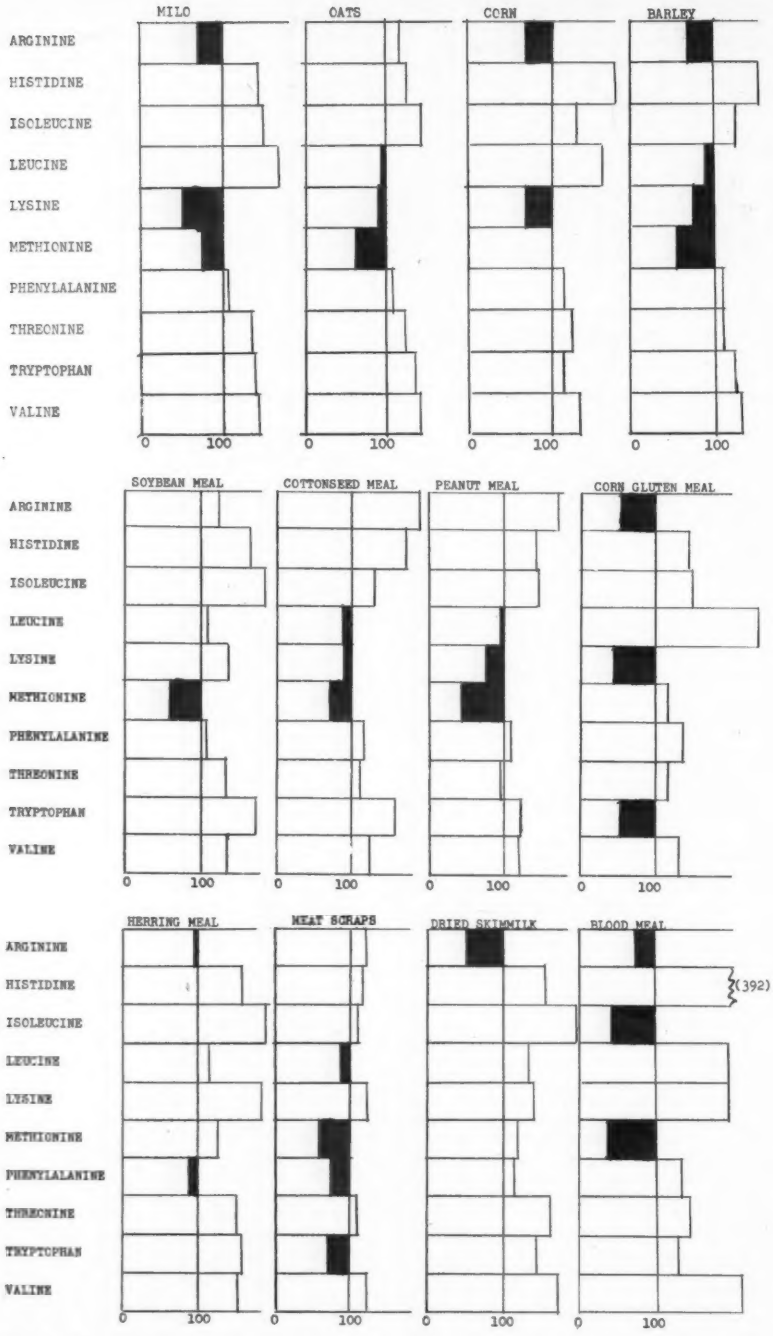


Fig. 5. Amino Acid Profiles of feedstuffs relative to chick requirements. Top, cereal grains; middle, certain vegetable proteins; bottom, certain animal proteins.

Animal By-Products. While of declining importance as a source of nitrogen for feeds, the animal proteins are useful in supplementing vegetable proteins. As a class, animal proteins are fairly high in lysine, and fish meal is useful as a source of supplementary methionine. (Fig. 5, bottom.)

Synthetic Amino Acids. In recent years there has been increasing interest in the use of synthetic amino acids to supplement natural feedstuffs. Synthetic methionine activity is widely used in commercial feeds. While there has been considerable interest in lysine, it is doubtful that it will have much place in the domestic feed industry, although in areas where only cottonseed, sesame, and peanut meals are available, it may be of considerable value.

Combining Protein Sources. In Fig. 6, the mutually supplementary value of corn and soybean protein is shown. Corn is rather deficient in arginine and lysine (and generally tryptophan), but contains a fair supply of methionine. Soybean meal, on the other hand, is rich in arginine, lysine, and tryptophan, but deficient in methionine. A combination of these proteins has higher value than either one alone, even though it is still slightly deficient in methionine. This deficiency can be made up by the addition of synthetic methionine-active compounds or by supplementation with other proteins, e.g. fish meal and corn gluten meal. This combination is the basis for the bulk of commercial feeds today.

Controlling Protein Quality

Because amino acid analysis does not lend itself to routine quality control, the formulator usually relies on his own or published analyses of feed ingredients. Analytical methods for amino acids are time-consuming and, unfortunately, not too accurate even in the hands of an expert. Thus, analysis of incoming ingredients and subsequent adjustment of formulas would at present be too cumbersome for efficient mill operation and likely would add little value.

Fortunately, natural products probably do not vary greatly (as percent of protein) in amino acid content. An exception to this is corn. Zein seems to be the protein in corn most responsive to changes in environment and breeding (10). As a result, the amino acid pattern in high-protein corn tends to shift toward that in zein, with lowered tryptophan and lysine. On the other hand, notwithstanding one report (12) of variation in the protein quality of oats, unpublished work[2] in our laboratory leads us to believe there is little variation in the amino acid pattern of oats even though total nitrogen may vary considerably. Little work on other grains has been published.

The most important variation

[2] R. W. Carroll.

in protein quality of feed ingredients, both as a result of variation in amino acid content and in digestibility, comes in processed ingredients – oilseed meals and animal by-products. During production of many protein feedstuffs, heat is applied to remove fat, to inactivate toxic principles, or for drying. During the course of heating, reducing sugars or other aldehydes present may react with functional nitrogen groups not protected by peptide linkages, such as the ε-amino group of lysine, the guanido group of arginine, histidine, and tryptophan. The bond thus formed cannot be hydrolyzed by the animal (8).

This reaction, known as the Browning reaction, has a twofold effect. First, lysine is generally most affected in this process, and since it is frequently the limiting amino acid, the loss in protein value will be proportional to the amount of lysine lost. Second, even if lysine is not limiting, the blocking of the ε-amino of lysine or the guanido group of arginine may interfere with over-all protein digestibility. The studies of Bergmann (4) have established that trypsin splits a protein molecule at the peptide bond containing the carbonyl of either lysine or arginine, provided the ε-amino of lysine or the guanido group of arginine is unsubstituted.

Since variations in processing may have such a great effect on the amino acid content and availability, quality-control methods, to ensure that the amino acids calculated to be present are present and available, are essential. Methods used are frequently short-cuts and may measure secondary factors which are only correlated with quality variations. With convenience and speed of determining primary objectives in developing such procedures, scientific precision and directness must occasionally be sacrificed. The following will serve to illustrate various procedures used in the feed industry.

Kjeldahl Nitrogen. While total nitrogen does not tell us anything about protein quality, it is still an important quality-control measure. Both feedstuffs and mixed feeds are traded on the basis of a protein (Kjeldahl $N \times 6.25$) guarantee. The feed manufacturer must follow a program which ensures that his guarantees are met, and since protein is expensive he will attempt to minimize his overage.

Further, nitrogen determination may provide some clues as to other aspects of quality. Low nitrogen content in some ingredients may indicate adulteration with nonnutritive materials.

Grains too may vary considerably in nitrogen. We have observed milo varying from 7.5 to 12% protein in different areas. Obviously a different problem of supplementation is encountered under such circumstances.

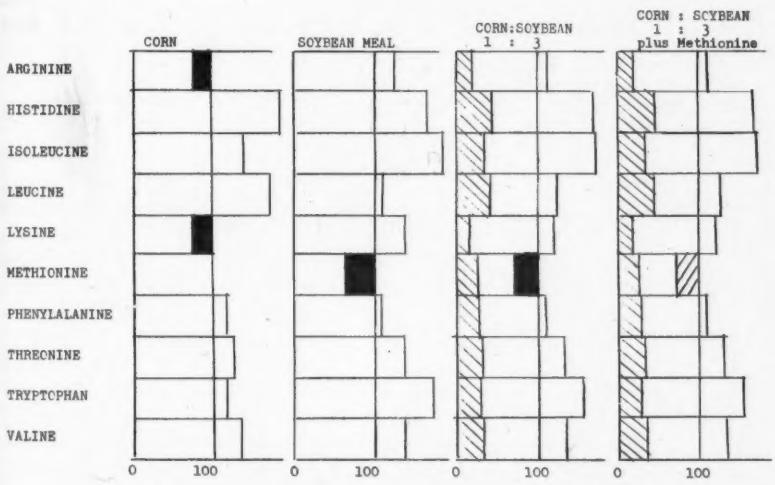


Fig. 6. Amino acid construction of a typical corn-soybean meal diet.

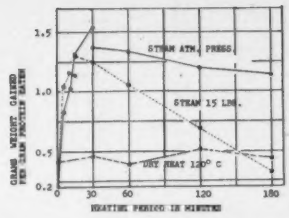


Fig. 7. Effect of type and extent of heat-treatment on nutritional value of soybean protein. (See ref. 7; reprinted by permission of the journal Food Technology.)

Soybean Meal. Since soybeans contain various heat-labile toxic factors, they require cooking before use. Figure 7 illustrates the effects of heat on the nutritive value of soybean protein. Heating under proper conditions raises the protein efficiency ratio (PER) from 0.2 to nearly 1.5 (7). To ensure that soybean meal received is adequately heated, we employ a test to measure the urease content. While urease *per se* is not detrimental in feeds for nonruminants, the destruction of this enzyme is reasonably well correlated with the destruction of the deleterious antitrypsin factor.

Also shown in Fig. 9 is the adverse effect of prolonged heating. This effect is apparently due in part to the Browning reaction, mentioned earlier, but also there is a destruction of cystine which is not fully understood. While in ordinary manufacturing practice overheating will be avoided from a quality-control viewpoint and also from the standpoint of unnecessary cost, a sensitive method for detecting overheated meals is needed by the industry.

Cottonseed Meal. The problem of maintaining proper quality in cottonseed meal is still not fully solved. Gossypol, which is present in the pigment glands of cottonseed, is quite toxic to nonruminants in its free form. However, removal of free gossypol generally entails pressure and heat to first rupture the glands, and second, detoxify it. Detoxification results when gossypol reacts with available amino groups. This, again, binds lysine which is the most susceptible compound available and since it is already limiting, further reduction in protein quality is almost unavoidable. Methods for

rupturing the pigment glands and removing some of the oil under mild conditions with subsequent solvent extraction of the rest of the oil have been developed and will produce a reasonably satisfactory product (1).

Quality-control methods established measure the amount of free and total gossypol to ensure that toxicity is reduced. The nitrogen solubility in 0.02*N* sodium hydroxide is determined to make sure that overheating did not result.

Meat Scraps. Problems of protein quality in meat scraps revolve mostly about adulteration and, to a lesser extent, the amount of heat-treatment. Unfortunately, meat scraps available in the trade are quite variable, containing such diverse things as hair, blood, sand, limestone, metal filings, and glass. The simplest, yet quite effective, control procedure is to examine each incoming sample under a microscope. With a small amount of training a microscopist can quickly detect adulteration, and with additional experience can give a reasonable idea of nutritive value.

Samples of meat scraps are also run to determine the amount of pepsin-indigestible nitrogen as a measure of availability. Various other determinations, such as carbonate and ash, may be made if particular contaminants are suspected.

Blood Meal. While isoleucine is the most deficient amino acid in blood meal, and variations in this amino acid would be most likely to affect protein quality if fed as a single source of protein, we are more interested in blood meal as a lysine source. Quality-control investigations have therefore led us to evaluate the variations in blood meal as a lysine source. Table II illustrates some recent work on this at our laboratory. Three commercial samples of blood meal were analyzed for lysine by conventional microbiological methods and found to contain similar amounts of lysine. These were then fed to rats, supplementing a lysine-deficient diet, and compared to a standard curve. While one of the sources of blood meal was a reasonably good lysine source, the other two were very poor. Sample C provided only half as much available lysine as Sample A. At present we have no convenient laboratory method to detect these variations in blood-meal quality, and the rat-assay method is too slow and costly for routine use. Under such circumstances, we must rely on so-called "Approved Supplier" lists. This entails checking a supplier's production before permitting purchases to be made from him, and subsequent intermittent checks on receipt of product.

Table II. Lysine Availability in Blood Meals: Rat-Growth Assay

	Lysine as Percent of Ingredient	
Blood Meal Source	*Microbiological Determination*	*Rat-Growth Assay*
A	10.5	6.9
B	9.3	4.0
C	9.2	3.5

Literature Cited

1. Altschul, A. M., Lyman, C. M., and Thurber, F. H. *In* Processed plant protein foodstuffs. Academic Press: New York (1958).
2. Baldini, J. T., and Rosenberg, H. R. *Poultry Sci. 34:* 1302 (1955).
3. Becker, D. E. Abstr., Proc. Minn. Nutrition Conf. (Sept. 14–15, 1959).
4. Bergmann, M. Advances in enzymology, vol. 2, p. 49 (1942).
5. Camp, A. A., Couch, J. R., and Quisenberry, J. H. *Poultry Sci. 36:* 171 (1957).
6. Grau, C. R., and Kamei, M. *J. Nutrition 41:* 94 (1950).
7. Klose, A. A., Hill, B., and Ferold, H. T. *Food Technol. 2:* 201 (1948).
8. Lienier, E. I. *In* Processed plant protein foodstuffs. Academic Press: New York (1958).
9. National Research Council. Pub. No. 301 (rev. 1954).
10. Sauberlich, H. E., Chang, W.-Y., and Salmon, W. D. *J. Nutrition 51:* 241 (1953).
11. Scott, M. L., Hill, F. W., Parsons, E. H., Brookner, S. H., and Dougherty, E. *Poultry Sci. 38:* 505 (1959).
12. Weber, E. B., Thomas, J. P., Reder, Ruth, Schlehuber, A. M., and Benton, D. A. *J. Agr. Food Chem. 5:* 926 (1957).

SABOTAGE!

The Unsolved Problem of the Food Industry

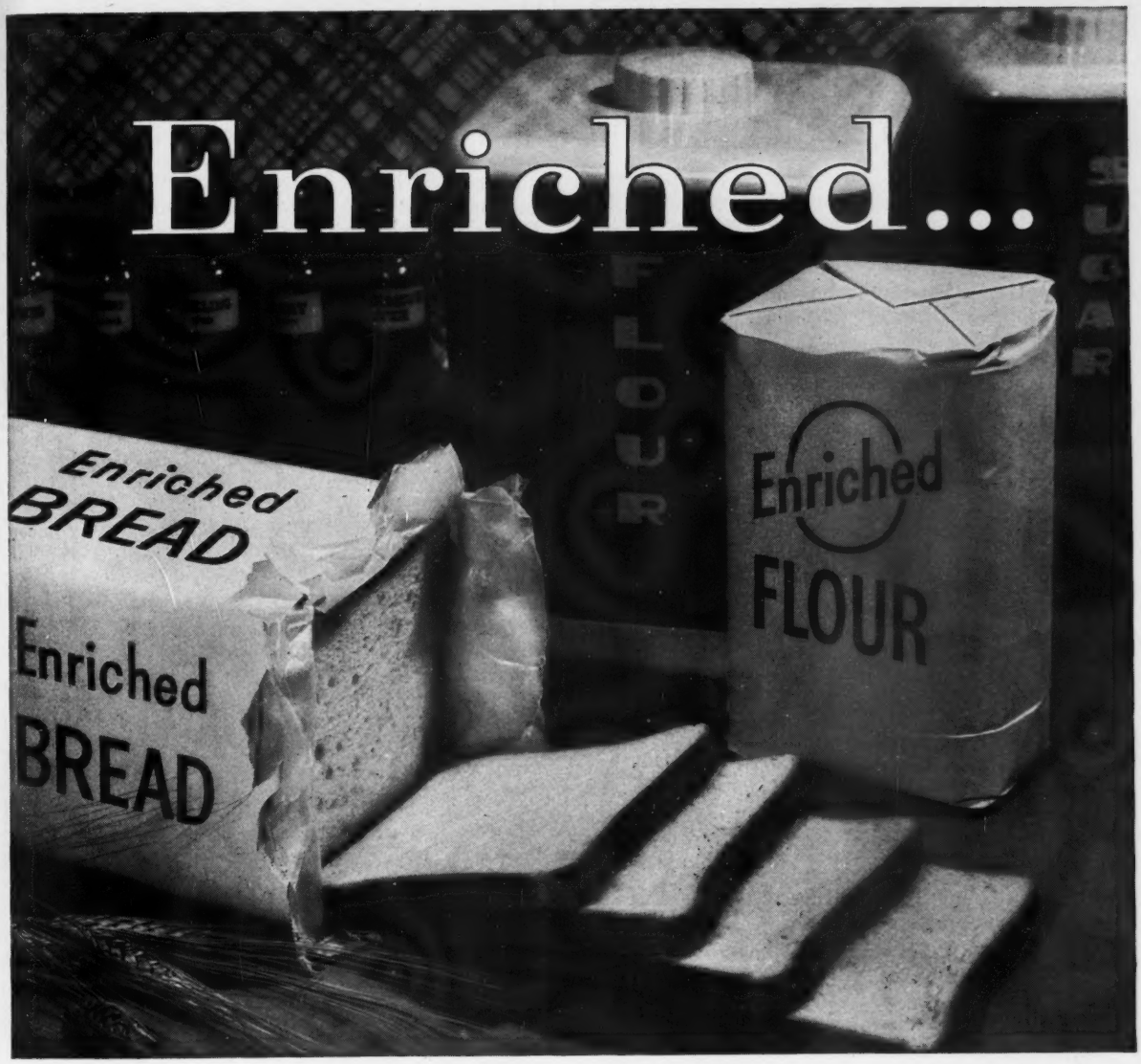
One of the topics for discussion at the Food and Drug Administration's Civil Defense Training Course for the AACC at Dallas, Texas, April 13-14, 1961, will be based on actual cases of infiltration of the food industry by possible saboteurs.

In this great nation of ours, where we have an ever-moving, shifting, job-swapping population, the problem of containing and controlling sabotage within safe limits becomes highly complex. Certain basic guidelines and defense measures can be taken to help solve the problem.

Key plant personnel represented by the AACC and other similar organizations of food-processing chemists are prime targets for enemy agents, since they usually have free access to all parts of their plant. Are you aware of the methods used by the enemy to secure your cooperation? Information will be supplied concerning these methods which can be helpful to everyone. "Forewarned is forearmed" was never more true than in the prevention of sabotage.

Manufacturers of sufficient size and wealth can install closed-circuit television systems along with other electrical devices to greatly improve their plant security. The utilization of these safety devices is one of the greatest advances taken to aid manufacturers in their battle against subversive elements. This will be discussed at Dallas.

We are vulnerable! It CAN happen here! Tomorrow may turn out to be yesterday if we do not, as individual citizens, find out about this and other civil defense problems, and then put this knowledge to work.



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*Report No. 6 in the Household Food Consumption Survey of 1955.

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AACC LOCAL SECTIONS

Southern California's November 1 meeting presented Sid Coyne, Coyne Chemical Co., with a talk on factors affecting the efficiency of contact insecticides used for fog spraying. He gave such information as the physical characteristics of the area being sprayed, type of insecticide formulations, and the efficiency of various types of sprayers.

The meeting time was changed from 7:00 to 6:30 p.m. Discussion of financial matters and suggestions for ladies' night completed this meeting.

On December 6, William H. Butz, Beckman Instrument Co., will speak.

New member: Sid Coyne.

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Chesapeake Section (October meeting, 27th) heard Peter Jvanovich Pogodin, agricultural attache of the USSR, speak on "The progress of agriculture in the Soviet Union," in conjunction with a documentary film of half-hour duration, general in nature. "Learning to know the Russian people on this very human agricultural level," said Walter T. Greenaway, Section vice-chairman, helps to make a "small personal contribution towards world understanding."

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Canadian Prairie Section's guest speaker at the October 18 meeting was Gerald Reed of Red Star Yeast & Products Co., Milwaukee. Dr. Reed outlined the manufacture of various types of yeast (dry granules, wet compressed); problems in manufacturing and methods of control; measuring yeast activity, stability and its effect on the commercial bakeshop; comparison of dry vs. wet yeast in commercial baking and methods of using each to obtain optimum results.

New members: Saul Zalik, University of Alberta; John W. Bradley, R. H. Kilborn, Mrs. C. J. Marek, H. C. Black, Grain Research Laboratory, Winnipeg.

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Pacific Northwest Section's annual convention, 1961, will be held in Portland; the date is as yet undecided. Committee chairmen will be Don Pitts, program; Eldred Walker, local arrangements; and Kenneth Twiggs, Allied Trades entertainment.

New members: W. Donald Lilly, General Mills, Inc., Spokane; Marvin R. Beranek, Terminal Flour Mills Co., Portland.

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Central States Section met in St. Louis on September 30. Guest speaker was C. Hollenbeck of Wisconsin Malting Co., Manitowoc, who gave members an informative talk on "The function of malt in baking."

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New York Section's October 11 meeting drew the fine attendance number of 93 members and guests. Speaker Robert H. Cotton, director of research for Continental Baking Co., described his recent European trip, visiting baking plants and research facilities in Germany, Holland, France, and Great Britain. Dr. Cotton said the amount and value of cereal research now being carried out in Europe is impressive. Areas in which results are promising are continuous mixing, the role of lipids in baking, and new instruments for evaluating the baking quality of flour.

New members: Anthony Leo and Donald Koedding, Continental Baking Co.; Harvey Fram and Morton Shaevel, B. Manischevitz Co.

On November 1 Russell M. Schultz, senior vice-president of National Biscuit Co., Fairlawn, N. J., talked on "What the biscuit and cracker industry expects from research." More and better effort is necessary, he said, in such areas as methods research, product development, and cost reduction. "We are living in an age where the rate of change is faster than ever before . . . Research will help us to run faster and faster; and more important, it will show us in what direction to run."

A 25-minute color film was shown, "Crackers by the Billion," describing biscuit and cracker production at the Chicago plant of the National Biscuit Co.

At the business meeting, the following committees were set up: 1) to study association membership classification; 2) local and national membership.

At the December 13 meeting (The Brass Rail), the speaker will be Truman L. Koehler, chief, statistical division, American Cyanamid Co. Mr. Koehler will speak on "Process statistics"; a general review of statistical methodology and its economical application to process improvement and development.

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Kansas City Section held a panel (September meeting) on white pan bread flour, moderated by Lester Fischer. Papers leading to discussions were: "Flour quality, uniformity, and specifications" – Mel Huber, Interstate Bakeries; "The kind of flour I want" – Paul Schmittoy, American Bakeries; "Flour for special processes, Patco-Kurl-Continuous" – Larry Marnett, C. J. Patterson Co. Participation and interest were good and the turnout was excellent – 40 present.

Lester Fischer reported on a proposed merger of Nebraska, Pioneer, and Kansas City sections, with a negative opinion indicated by KC members. Lester Fischer, Larry Marnett, and Elmer Modeer were appointed as a committee to continue study of the merger.

Speakers at the "Particle Size Analysis" symposium held during the AACC's Tri-Section meeting, October 7-8, 1960. Front row, left to right: Jason C. Annis, R. R. Irani, A. R. Handleman, Kenneth T. Whitby. Back row, left to right: Ben Grogg, P. R. Crowley, John A. Johnson.

Midwest Section was host on November 7 to AACC National President John A. Johnson, for cocktails and dinner at the Builders Club. Dr. Johnson gave news of Association affairs, and then described his research on the browning reaction in baked goods.

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Cincinnati Section voted at its October 7-8 meeting (17th annual joint meeting with Ohio Valley AOM) to go on record as favoring establishment of a living

memorial fund for deceased members. A specific recommendation will be made to the board of directors for consideration.

J. R. Hedding of Marion Milling Co., Marion, Ohio, has been appointed membership chairman.

New members: Grant Pearcy, The Pillsbury Co., Minneapolis; Dennis Wade, Lyon & Greenleaf, Inc., Ligonier, Ind.; Henry Wirth and Dick Pierce, Kroger Food Foundation, Cincinnati.

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Niagara Frontier and **Toronto Sections** held their 10th annual Trans-Border Meeting in Buffalo on October 22, jointly with Niagara District AOM. The morning program included talks on "Cereal products under new U. S. Food and Drug amendments" by FDA regional director Allen T. Retzlaff; and a panel discussion on "Bulk flour deliveries from the baker's viewpoint," afternoon papers were: "Grain crops—varieties, yields, and exports"—W. Grindley, Toronto Elevators Ltd., Winnipeg; "Harnessing the power of people"—Allan M. Darroch, Loblaw Inc.; and "Use of impact machines in flour milling"—Ernst Auer, Miag Northamerica, Inc. A panel on " A current example of food faddism" was moderated by Lyle C. Mertz, General Mills, Inc. Evening enjoyments were banquet, entertainment, and dancing.

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the President's Corner

news of the association

The American Chemical Society dedicated its new headquarters building in Washington, D.C., on October 7. Your Association Representative, Kenton Harris, records here his impression of the place of the cereal chemist in the total area of chemistry.

"As cereal chemists, many of you must sometimes wonder, as do I, just where we fit into the large field called *chemistry*. A few weeks ago I had the pleasure of attending the dedication ceremonies of the new building of the American Chemical Society in Washington. My report could dwell on the reception, on the luncheon, or on the dedication of a most impressive edifice that stands on Sixteenth Street north of the White House and near the Statler Hotel, the new Wildlife Federation Building, the National Geographic Society, and so on, but I was most impressed by being able to represent our Association at a meeting that numbered among its guests some of the outstanding chemists of our time.

"Each individual and each organization represents a part of the whole science of chemistry, which in these times has become more and more a complex mosaic that is complete, only insofar as each piece is present and each is as bright and clear as the next.

"The whole situation set me thinking that cereal chemistry itself, its very progress and fate, depend upon the zeal with which each of us carries on his individual duties; but the individual is obscure unless he speaks through a group. It is our group, the AACC, that places us in the larger one made up of thousands of professional chemists. These men, each a delegate of some group, no longer have the time or scientific know-how to cover what we *used* to call chemistry, and each depends upon the others to keep the whole picture intact. It may sound corny on the printed page, but in the real glow of this outstanding group of scientists and in the framework of a truly radiant situation, it seemed to me that the position of the American Association of Cereal Chemists is such that it cannot be set off in a corner; not without diminishing the stature of the whole science of chemistry.

"At times we may feel that cereal chemistry is taking a back seat in a civilization and economy that bestow immediate greatness on nuclear chemists, space explorers, and other headline makers. But each of us, as a professional scientist, knows that the less dramatic issues are still in the hands of those who will keep them alive."—Kenton L. Harris, *Chairman*, Technical Policy Committee.

JOHN A. JOHNSON

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People, Products, Patter

• • • People

Dean Foster appointed manager of new Food Division of United States Testing Co., Hoboken, N. J. An international authority in testing, research, and development, Dr. Foster will head a team of 15 specialists who have been recruited to expand and broaden special programs in food research and testing for clients in the food industry.

Frederick L. Dunlap died on October 8 at Westlake, Ohio, aged 90.

Dr. Dunlap was an original member of the U.S. Board of Food and Drug Inspection. He served from 1907 to 1912 as an Associate in the Bureau of Chemistry of the USDA, and during the same period was Board member, Food and Drug Inspection. He was a consulting chemist for many years, with Victor Chemical Works, 1912 to 1915, and with Wallace & Tiernan, Inc., 1930 to 1960.

He is survived by a son, Stanton, and daughter, Mrs. Rosalie Boyle, with whom he resided in Shaker Heights, Ohio, at the time of his death.

Dr. Dunlap was a gentleman of the old school, courteous even in the adversity of losing a leg from circulatory disease in 1937. Cereal chemists will remember him for his personal attributes and his contributions to their profession in solving baking-powder problems, as well as those of flour bleaching and maturing.

George M. Frauenheim elected president of Barley and Malt Institute; he is president of George J. Meyer Malt & Grain Corp., Buffalo.

Kenneth C. Hayes appointed manager, technical service department, American Machine & Foundry Co.'s R & D division; will coordinate and direct activities of shop facilities, engineering standards, process analysis, technical communications, and technical information and library groups.

E. J. Kitely transferred to Montreal, Canada, with International Milling Co

Charles G. Mortimer elected to second term as president of The Nutrition Foundation. He is chairman of General Foods Corporation.

John H. Neufeld, The Pillsbury Co., retires as director of personnel after 32 years with the company; was instrumental in establishing and developing its personnel function. **Robert D. Watson** appointed director of personnel and organizational planning for Pillsbury; has directed the latter under Mr. Neufeld. The two departments are now combined.

Ludvig Reimers is "enjoying retirement" by seeing the world: in recent months has visited the South Sea Islands, New Zealand, and Australia in a three-month trip; has taken one of two months to Japan, Manila, and Hong Kong; now has just returned from Europe.

Russell J. Stenberg died in Minneapolis on November 10, at the age of 43.

Dr. Stenberg was with the USDA's Northern Regional Reseach Laboratory, Peoria. Previously he had a position with the ADM Co., Minneapolis. Stenberg was the author of a number of research articles published in his field, many of which appeared in CEREAL CHEMISTRY. He was a member of the AACC since 1947.

He is survived by his wife, Audrey; two sons, Jon and Peter; two sisters, and three brothers.

• • • Products

Merck expands MSG facilities. The Chemical Division of Merck & Co., Inc., is doubling the productive capacity of its monosodium glutamate plant in Danville, Pa.; completion scheduled for mid-1961. The company thus backs its belief in a bright outlook for increased use of MSG, which it produces by a new, technically advanced fermentation process. Production was started in the summer of 1958 with an investment of $4.5 million at the Danville plant; the present expansion calls for expenditure of $2 million.

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Laboratory instruments. The Sargent Hot Plate-Magnetic Stirrer and Electric Heater are the subject of Bulletin HP-A, just released. The stirrer features 750-watt maximum output; three heat positions; stainless-steel case that will not overheat; variable stirring. The heater: seven-step control; stainless-steel construction; 750-watt output. "All this," the company says, "at a low price." Your copy will be sent on request to E. H. Sargent & Co., 4647 W. Foster Ave., Chicago 30, Ill.; Dept. HP.

• • •

Propylene glycol alginate is now authorized (by U.S. Food & Drug Commissioner) for use as a stabilizer in confectionery and frozen desserts, in addition to previous use to emulsify, stabilize, or thicken various other foods for human consumption. Products of the Kelco Company of New Jersey specifically covered are Kelcoloid HVF, thickener for fruit syrups and sauces; Kelcoloid O and LVF, emulsion stabilizers for salad dressings, meat and barbecue sauces, frozen food batters. All three are used in flavor emulsions and beverages. In various frozen foods the algin products are said to retard ice crystal formation, discourage weeping, and release flavors.

• • • Patter

Food research and testing. A Food Division of United States Testing Co., Hoboken, N. J., has been formed to provide services in testing, research and development, analysis, and product evaluation for the food, beverage, and confection industries. Specialists with experience in chemistry, microbiology, engineering, psychology, and market research will take charge of a full program, from the concept of a product to nationwide marketing studies. The company will contract for all or a part of any such program, depending on the client's need.

Materials, products, and processes to be serviced are: agricultural or chemical raw materials, edible or potable; formulations; processing equipment and effects; packaging materials and designs; flavor,

When not to use our emulsifier

The nice, stiff pudding at the left does *not* contain any of our *Myverol® Distilled Monoglycerides*. The starch amylose molecules set free during cooking have congregated into a jelly-like matrix that gives the pudding its texture. If this is the way you like a pudding to be, don't put *Myverol* into it.

The syrupy, runny pudding at the right *does* contain only 0.4% of *Myverol Distilled Monoglycerides*, Type 18-00. Notice the effect on texture.* Free dissolved amylose has gone into hiding, complexed so securely by high-purity monoglycerides that even the familiar blue-color test can scarcely find it.

This might give someone an idea for engineering the texture of a starch-based sauce, fountain syrup, or gravy. You can control it—more emulsifier, less viscosity.

These emulsifiers are safe. We prepare them by glycerolysis of vegetable and animal food fats. You can use them without worrying about the Food Additives Amendment. For samples, information, and prices, write ***Distillation Products Industries,*** Rochester 3, N. Y. Sales offices: New York and Chicago • W. M. Gillies, Inc., West Coast • Charles Albert Smith Limited, Montreal and Toronto.

*Curiously enough, just the opposite is true with chocolate sauce. More monoglycerides, more viscosity.

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– ANNOUNCING –

The 2nd Annual Ingredient Symposium

(Flour)

The Central States Section of the AACC will hold its 2nd annual ingredient symposium in Peoria, Illinois, on January 27 and 28, 1961. The following topics will be covered: flour protein; lipids; enzymes; carbohydrates; soft wheat performance testing. A panel discussion will conclude the meeting. A detailed program will be published in the next issue of CEREAL SCIENCE TODAY. All interested persons are invited to attend.

color, and extending additives; processing and preserving agents; pesticides and antimicrobial agents; and all conditions affecting final quality and shelf-life. The division will also supply services in marketing and distribution, development and diversification, quality control, and process study.

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USDA studies on MSG. In the Western Utilization R & D Division, Albany, Calif., workers have investigated, by taste-panel and chemical research, the use of monosodium glutamate in foods as a flavor adjunct. Among the more important points in question were its detection and preferences for amounts added; whether it masks or reduces off-flavors; and how it is affected by canning. Observations were that in foods low in natural glutamate, added MSG is readily detected; in those with a relatively high natural amount, additions have less effect. Food manufacturers, then, can use the natural content as a guide to amounts to be added. Levels of thickening agent, fat content, and seasonings normally used did not greatly influence ease of detection. In frozen foods, addition of MSG did not reduce the rate of development of off-flavor, nor mask the off-flavor. In several canned foods studied, glutamate was retained without loss, whether added before or after canning. Preference tests showed that foods with added glutamate were generally preferred over those without it.

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Nutrition information. A national information program to bring knowledge about nutrition to the general public, in readily understandable terms, is being launched by The Nutrition Foundation, Inc. The plan, according to the announcement, is to invoke the aid of scientific and technological authorities as sources for newspaper, magazine, television, and radio material. Articles and discussions on good nutrition are to be stimulated by providing media people with reliable information tailored to their respective needs.

Sipherd:

(Continued from page 310)

a high-enzymatic malt, which they are able to produce without the use of gibberellin.

We specify our purchases of malt not to exceed 250,000 viable bacteria cells per g. If the malt does not exceed that count, we can ferment our mashes under essentially sterile conditions. The reasoning behind this is that at the time of setting of the fermentors with yeast, the number of yeast cells greatly exceeds the number of bacterial cells per unit measure; the yeast count will increase at a much more rapid rate than the bacteria, and this will reduce the bacterial count to a relatively negligible level.

The combined benefits resulting from the improvements we have made in design of equipment and the lowering of the bacterial count of the barley malt are:

1. The distiller can mash continuously for at least a week without having to shut down for a cleanout. (We used to be forced to shut down at least once in 24 hours.)
2. Our alcohol yields and fermentation efficiencies are greatly increased.
3. Distillate of more uniform quality is produced, having no off-odors from harmful bacteria.
4. Design and installation require less costly equipment.
5. Longer and larger fermentations are possible.

A Glance at the Future

Many more improvements can yet be made. Now in progress is a plant test of conversion of starches using barley malt whose enzymatic activity has been stimulated by a special plant hormone. Through the use of gibberellic acid, or the potassium salt of the acid, the enzymatic content has been nearly doubled. Other than the two known enzymes, alpha- and beta-amylase, we do not know whether there are any that are beneficial, which have been stimulated by gibberellin. We hope to know soon.

Before we can advance much further and understand the limits of our efficiency, we must have a better practical method to determine the percent of true fermentable carbohydrate of starch. The steps in solving this problem must be taken in the laboratory. We solicit the cooperation of CEREAL SCIENCE TODAY's readers in making a study of this problem.

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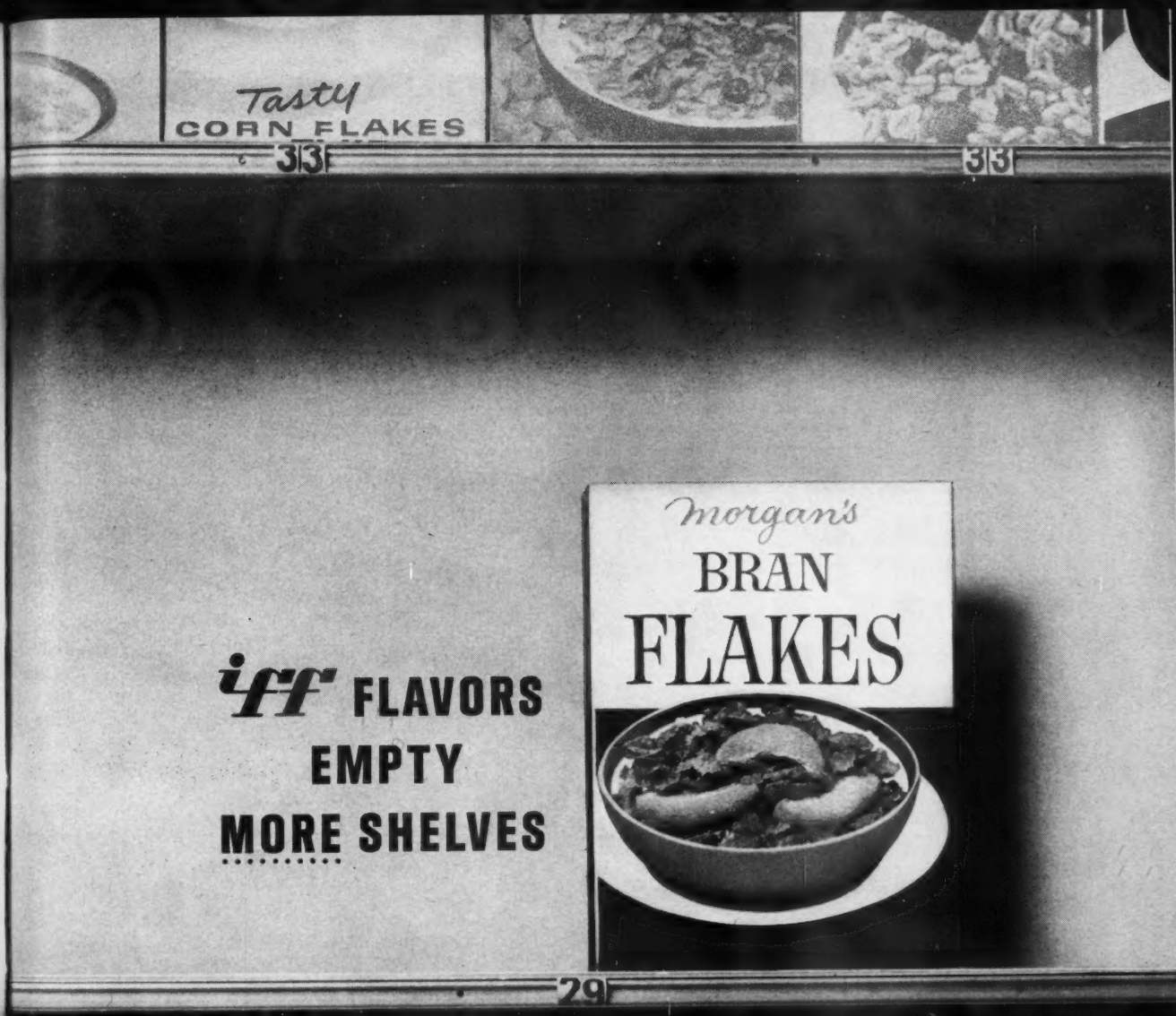
Cereal Chemist and Food Technologist – twenty years of varied and responsible experience in products control, research and product development – excellent background in commercial baking and baking technology; seeks promising position in product development and/or technical service. Reply to: Dept. 10F, CEREAL SCIENCE TODAY, 1955 University Avenue, St. Paul 4, Minnesota.



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